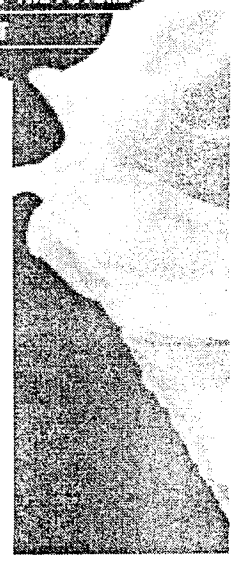

IX. Key Beneficial Characteristics of Individual Whey Components

Science is incredible. It is amazingly persistent - indeed, relentless! - in the pursuit of bettering the human condition. Over the past 20 years, dozens of reports involving hundreds of scientific researchers and representing thousands upon thousands of hours in the lab have resulted in a huge body of knowledge covering whey protein's fantastic, far-reaching effects on health, nutrition and disease-free longevity.

It is beyond the scope of this Whey Protein Report to delve with extensive detail into the many actual and potential biological properties and benefits of whey. Suffice it to say that whey has established itself as an incomparable, physiologically functional food, as evidenced by the following discussion of the key characteristics of individual whey proteins. In accordance with other current studies, the proteins are presented, for the most part, in order of their decreasing concentration in whey.

Beta-lactoglobulin

Beta-lactoglobulin (lactoglobulin) is the most abundant protein, comprising between 50-60% of whey. Being the biggest does not make it the best, in terms of biological activity. Despite much speculation and a fair amount of research, no specific lactoglobulin bioactivity has been determined to date. Some researchers surmise that it operates as a possible transport protein for retinol.

Since human milk does not contain lactoglobulin, the next component - alpha-lactalbumin - is the preferred ingredient in "humanized" infant formula.

Alpha-lactalbumin

Alpha-lactalbumin (lactalbumin), makes up 25% of total whey protein. Its excellent amino acid profile is rich in lysine, leucine, threonine, tryptophan and cystine, and it is a calcium metalloprotein. When milk is heated, the lactosylated form of this component binds to E. coli.

In a sleight of recent studies (1999-2001), lactalbumin has been correlated to the following bioactivities:

- Anticancer (Svensson M et al., 1999 and 2000).
- Antimicrobial (Pihlanto-Leppala A et al., 1999 and Pellegrini A et al., 1999).
- Stress reduction (Markus CR et al., 2000). In this study, lactalbumin was shown to raise brain serotonin, reduce cortisol concentration and improve mood under stress.
- Immunomodulation (Montagne PM, 2000).

Immunoglobulins

Immunoglobulins (Ig) are not a single component of whey, but rather a complex group of proteins that together exert a critical immunological function, especially in colostrum. The group includes IgA and secretory IgA, IgM, IgE, various IgGs and other components.

As delineated in previous scientific literature (Buttler, 1974; Lascelles, 1979), all immunoglobulins are glycoproteins. The monomers or polymers are composed of two light chains (approximately 20,000 D) and two heavy chains (approximately 50,000-70,000 D) linked together with sulphide bonds.

To date, studies of benefits have focused on newborn ruminants. Recent research is looking at effects on non-ruminants and adults.

- The Ig of milk and colostrum provides passive immunity to newborn ruminants.
- Igs may also protect against gastrointestinal disease in both ruminant and non-ruminant adults.
- In one key function, Ig prevents adhesion of microbes to surfaces and neutralizes toxins and viruses.
- Certain research (Hilpert, 1980) describes the immunization of cows with specific antibodies to produce "hyper-immune milk." This product has been produced/marketed in Asia.
- Hilpert documented the collection of milk from cows immunized with the E.coli vaccine to prepare a whey protein concentrate used to protect young animals from disease.
- According to Korhonen (1998), immune milk might be targeted to specific consumer groups in the future.
- In one double-blind, clinical-trial study (Sharpe et al., 1994), immune milk was suggested to lower blood

pressure.

- Ig's antivirus activities in the colostrum of cows to prevent diarrhea have been reported in recent research (Song G et al., 1999).

A note about proportions

The precise amount of specific Igs in whey from commercial milk supplies varies, depending upon the exposure of (thousands of) cows to antigens in their natural environment. Thus, due to the wide range of different Igs present, the type of levels in the end product may differ widely. Nevertheless, when whey protein concentrates are treated to avoid denaturation, the products generally contain sufficient antibody to E. coli K-99 to meet USDA requirements of a colostrum supplement.

Bovine Serum Albumin (BSA)

BSA is a large globular protein (MW: 66,000 D). Boasting a good essential amino acid profile, BSA binds free fatty acids and other lipids and flavor compounds that, according to Kinsella and Whitehead (1989) can alter the heat denaturation of the protein.

The functional properties of BSA in whey protein concentrates have not been explored in any detail. BSA comprises only about 5% of the protein in whey protein concentrates. Here is what is known today:

- In vitro, BSA protects lipids against phenolic-induced oxidation (Smith et al., 1992).

- In a study of anti-mutagenic effects of various proteins (Bosselears et al., 1994), BSA was effective against genotoxic compounds. Soy protein and other ingredients were not.

- BSA has been utilized as a component of cell media to enhance production of plasminogen activator (Tallman & Malibu, 1996).

- Most recently (Tong LM et al., 2000), BSA's antioxidant activities have been explored in the Journal of Agricultural and Food Chemistry (48; 5: 1473-1478).

Proteose-Peptose (PP) Fractions

PP fractions are the acid, heat-stable protein components in milk. Unfortunately, very little research exists. Most is focused on PP3, which according to Girardet et al. (1993) is an inhibitor of pancreatic lipase.

Lactoferrin

Lactoferrin is made up of a single peptide chain (MW: 77,000 D). It is a major whey protein in human milk. Bovine colostrum and milk contain a lower lactoferrin content, however the component's functionality is similar.

The Baylor School of Medicine received three patents in the 1990s covering the cloning of lactoferrin and lactoferrin peptides for therapeutic and nutritional applications. An array of lactoferrin-related patents (1983-1997) points to the ingredient's potential in a number of areas, from infant diarrhea and support for newborn growth (Nichols & McKee, 1988) to food and pharmaceutical applications (Dubois, 1988).

Lactoferrin is an iron-binding protein rich in bioactive functionality. For that reason, it has received much attention in the research field. Initially, interest focused on lactoferrin's capacity of acting in iron transport and as an antimicrobial agent, due to its iron-chelating ability. In terms of biological activities/benefits, lactoferrin is a highly significant whey protein. Lately (Shimazaki, 2000) the component's multiple potential health benefits are expanding into the following areas.

- General benefits have been addressed in at least ten publications over the last three years (1999-2001). These include explorations of the extra benefits of lactoferrin (Potjewijd R, 1999) and investigations into the usefulness of bovine lactoferrin in animals and, importantly, in humans (Yamauchi K, Teraguchi S & Hayasawa H, 1999).

- Anticancer support has been established for mice and rats (Iigo M et al., 1999; Noorrby K et al., 2001 and others). A recent study on the role of dairy products in cancer prevention (Tsuda H et al., 2000) focused on lactoferrin's biological activities.

- Antimicrobial studies have been extensive, beginning with Arnold et al. (1979) and continuing through research on the protective effects (Valenti P et al., 1999) and antibacterial effects (Venkitanarayanan KS et al., 199) of lactoferrin. Kawasaki Y et al. (2000) reported on lactoferrin's inhibitory effect on the adherence of E. coli to host cells.

- Synergistic effects from the combination of lactoferrin, lactoperoxidase and beta-lactoglobulin have been shown to eliminate certain microorganisms in mice and thus prevent death.

- Antiviral benefits have been explored, demonstrating that lactoferrin is an effective protector against several viruses (Marchetti et al., 1996; Shimazu et al., 1996). Recent studies have examined lactoferrin's effectiveness in inhibiting/fighting hepaptitis C, hantavirus, HIV and other serious infections.

- Antioxidant work has looked at lactoferrin's inclusion in infant formulas (Satue-Gracia MT et al., 2000).

- Immunomodulation studies have focused on lactoferrin's effects on mice (Debbabi H et al., 1998), Atlantic salmon (Lygren B et al., 1999) and humans (Miyauchi H et al., 1998).

- Insulin-like growth factor (IGF) research is at the beginning of the curve (Baumrucker CR & Erondu NE, 2000).

- Iron transport, the focus of initial lactoferrin research, is of continuing importance. The China Dairy Industry (Jiang DM, 1999) recently researched the effects of iron-saturated lactoferrin on iron absorption.

- Peptide derivatives of lactoferrin (produced by the action of pepsin on lactoferrin) have been shown to promote enhanced antimicrobial action. One study (Konig et al., 1995) examined an immuno-stimulating, lactoferrin-derived peptide's ability to modulate release of inflammatory mediators from immune system cells.

Lactoperoxidase

Lactoperoxidase is the second most abundant enzyme in milk (after xanthine oxidase), found almost exclusively in whey, lactoperoxidase is a glycoprotein made up of one peptide chain (MW: 78,431 D).

Reiter and Perraudin (1991) identified lactoperoxidase as an antimicrobial agent present in milk, saliva and tears. As reported in detail by DeWit and Hooydonk (1996), the lactoperoxidase system (LP) is an important part of the natural host defense system protecting against invading microorganisms. In addition to the following health benefits, LP may act in synergism with other whey ingredients, including lactoferrin.

- Preservative benefits have been demonstrated in experiments involving pasteurized milk (Barnett NE et al., 1999 and several others), cheese (Atamer M et al., 1999) and red meat (Kennedy M et al., 2000).

- Antimicrobial effects have focused on LP's role in the thermal resistance of salmonella (Dyle ME & Mazzota AS, 2000) and both raw (Heuvelink AE et al., 1998) and mature (Shin K et al., 2000) milk.

Peptides

Bioactive peptides derived from milk and whey proteins have been evaluated to determine their role in several areas of health preservation, from lowering cholesterol to protecting against hypertension and cancer. For this reason, researchers have increasingly directed their attention to peptides and biological activities, both in the direct form of neurotransmitters or indirectly through their role in immune response and the secretion of hormones and enzymes from intestinal transmitters (Maubois & Leonil, 1989; Meisel & Schlimme, 1990; Steijns, 1996 and others).

Among the whey proteins providing bioactive peptides upon digestion are alpha-lactalbumin, beta-lactoglobulin, lactoferrin, BSA and the casein glycomacropeptide (GMP). GMP is remarkable in many ways. Exploratory science today is only scratching the surface of its potential.

GMP offers multifaceted health benefits

GMP is found in sweet whey, not acid whey. It has a unique amino acid composition; it lacks aromatic amino acids and is enriched in branched-chain amino acids (BCAAs). Due to its composition, El Salam et al. (1996) posited that GMP might be effective in diets to control liver disease, in which BCAAs may be used as a carbon source.

The following effects show GMP's wide-ranging potential benefits. To date, studies have been performed on laboratory animals, with no confirmation of the benefits in humans. Nevertheless, evidence is mounting that the GMP prepared commercially from whey and available in functional foods supports the 1) binding of cholera and E. coli; 2) inhibition of bacterial and viral adhesion; 3) promotion of bifodobacterial growth; 4) modulation of immune system responses; and 5) gastric secretions.

In humans, foods based on whey proteins have been developed for infant formulas and special dietary uses. These include whipped products, meringues, biscuits and fortified fruit jellies.

- General nutritional benefits of GMP have been investigated in the British Journal of Nutrition: "Biological Activities of Bovine Glycomacropeptide" (Brody EP, 2000) and other sources.

- Antiviral effects involved in inhibiting Herpes Simplex virus type I; Sicilian R et al., 1999.

- Anti-cancer potential in human leukemic cells; Yoo YC et al., 1987.

- Decreased risk of cardiovascular disease; Pfeuffer M & Schrezenmeir J, 2000.

- Antihypertensive benefits have been explored in over ten studies in just the past three years. These have been published in prestigious international publications including the British Journal of Nutrition, the Bulletin of the International Dairy Federation, the Journal of Japanese Society of Nutrition and Food Science, and the International Dairy Journal.

Research is also ongoing in the exploration of GMP and other whey peptides' role in the following benefits:

- Antithrombotic.
- Cholesterol.
- Growth factor.
- Opiod-like effects.
- Antioxidative.
- Antimicrobial.
- Anti-inflammatory.
- Immunomodulation.

Benefits of other peptides

With much attention devoted to the rich potential of GMP, relatively little has been focused on other biologically active peptides of whey. However, research is not at a standstill in this area. Investigatory work has been done (Kang et al., 1996) on the structural-antimicrobial activity of lactoferricin, a basic peptide derived from lactoferrin. It has been proposed that the basic amino acid portion of lactoferricin may play a significant role in antimicrobial activity.

Whey lipids are another promising field for future inquiry. High protein (80%) whey protein concentrates may contain as much as 6-8% lipid, of which half are phospholipids. Over one-third of the phospholipids in whey are sphingolipids, which have been suggested to have anti-cancer activity. In one recent study (Schmelz & Merrill, 1998), dietary sphingomyelin was demonstrated to inhibit the early stages of colon carcinogenesis and also to inhibit tumor progression from a benign form to malignancy.

Other whey factors

Science is still identifying and investigating the biological activity of other beneficial factors from whey protein. Factors that may not only stimulate the growth of a number of cell lines but also provide wound healing.

Interestingly, some commonly known ingredients are beginning to be explored beyond their known benefits. For example, the nutritional value of minerals and vitamins present in milk products has been well established, but now, their role beyond nutrition in the area of bioactivity is being explored. In 2000, the U.S. Food and Drug Administration (FDA) announced that dietary supplements could claim "heart health" benefits on product labels if those products contained vitamins B12, B6 and folate found in whey, yogurt and cow's milk. Other ingredients of whey may also be beneficial, such as...

- Calcium may help regulate blood pressure (McCarron DA, 1998).
- Phosphopeptides may help prevent dental carries and support immunomodulation (Otani H et al., 2000).
- Oligosaccharides and nucleosides in whey may enhance bifidobacterial growth (Gopal PK & Gill HS, 2000 and others) and serve as prebiotics (Walker WA & Duffy LC, 1998).

<< Back | Section 10: Whither Go Whey: The Future in Scientific Research and Commercial Manufacturing >>